Modelling crisis management for improved action and preparedness (CRISMA): Modelling submersion on the Charente-Maritime coast

Mehdi Pierre Daou, Agnès Cabal, Christophe Coulet, Olivier Bertrand, Eric Blayo, Antoine Rousseau, Arnaud Degroof

CRISMA

Modelling crisis management for improved action and preparedness

Modelling submersion on the Charente-Maritime coast

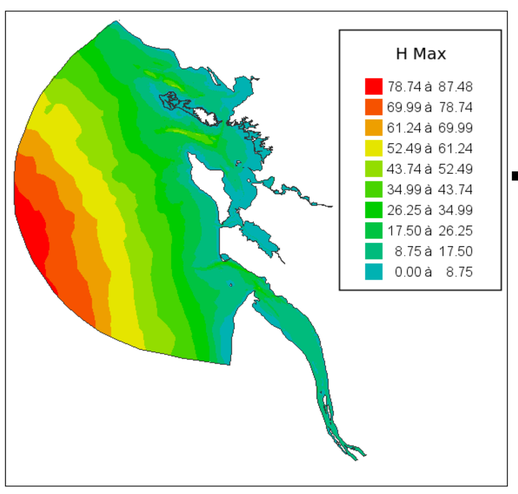
Mehdi Pierre DAOU • Agnès CABAL • Christophe COULET • Olivier BERTRAND • Eric BLAYO • Antoine ROUSSEAU • Arnaud DEGROOF

Abstract: CRISMA is a Research and Development project financed by the European Community. Its objective is to develop a simulation-based decision support system, in different domains of the natural or industrial risk (flood, snowstorm, seism, forest fires, accidental pollution, urban accidents). The application in France, coordinated by ARTELIA Eau & Environnement, is devoted to the submersion risk on the Charente-Maritime coast and based on the experience feedback of the storm Xynthia in February, 2010.

In this framework, a specific work is in progress through a thesis realized in collaboration between ARTELIA and INRIA . Its objective is to elaborate a methodology of multi-model coupling which should be effective and applicable for the CRISMA project. These models may differ in several ways, related either to the physics and/or to the numeric concepts. The developed methodology may allow to taking into account more specific areas (urban zone, bridge in charge, …), but also should be able to simplify the simulation by dimension changes of model parts (for example, a 1D model for rivers, and a 2D one for sea). The present work addresses more specifically the problem of coupling models with different spatial dimensions.

Implementation of a user defined dike behaviour with the help of Damage Probability matrix

Global scale modelling



Potential statistical impact on dikes depending on their individual status

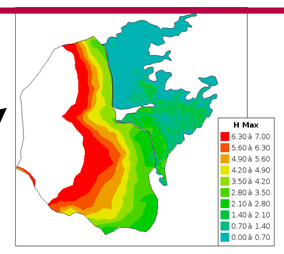
User defined decision

–Dike will totally fail
–Dike will breach
–Dikes will “Hang on”

The impact on dikes
Damage probability matrix

Water level above the dike	Status		
	Good	Medium	Poor
<20 cm	99,9% No failure 0,1% Breach 0% Total Failure	99% No failure 1% Breach 0% Total Failure	10% No failure 80% Breach 10% Total Failure
20 to 50 cm	99% No failure 1% Breach 0% Total Failure	10% No failure 80% Breach 10% Total Failure	5% No failure 15% Breach 80% Total Failure
>50 cm	98% No failure 2% Breach 0% Total Failure	5% No failure 15% Breach 80% Total Failure	0,1% No failure 4,9% Breach 95% Total Failure
>1 m	10% No failure 80% Breach 10% Total Failure	0,1% No failure 4,9% Breach 95% Total Failure	0,0% No failure 0,1% Breach 99,9% Total Failure

Local Scale modelling

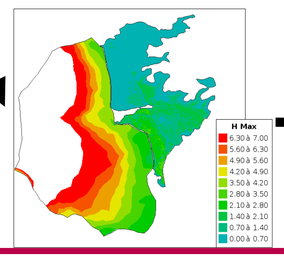


Taking into account user defined dike behaviours

Computation of indicators

(Economics impacts, Ecological impacts, Social impact, Impacts on networked services)

Key performance Indicators comparison



Local Scale modelling

Taking into account user defined dike behaviours

Computation of indicators

Models :
- **Hazard of coastal submersion modelling**
- **Vulnerability model**
- **Computation of indicators**

Coupling method

Models :

- The Coupling methode :
  - Navier Stokes 3D equations (Telemac3d module)
  - Shallow watter 1D equations (Mascare module)
- Managed communication : Open-Palm
- Coupling Method : Schwarz
  → iterative method, few intrusive

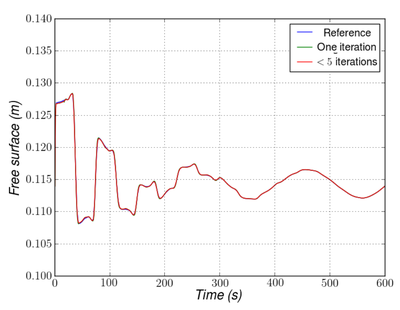
Conditions :

- No bottom friction Ks → +∞ and v = 10^{-6} m^2 $.s^{-1}$
- **Initial Condition** :
  – U = 0 $m.s^{-1}$ and constant height Z_s=0.114 m
- **Boundary conditions :**

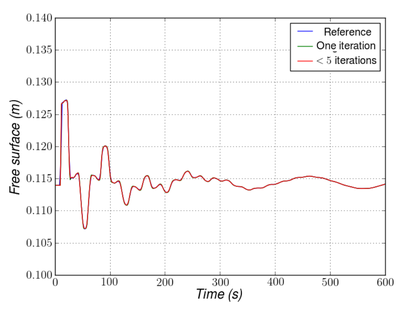
$$\begin{cases} U\cdot\vec{n}=0 \quad \text{no flow through solid boundaries (bottom and lateral)} \\ U=U_d(Q_d) \quad \text{at the input} \\ Z_s=Z_{sd} \quad \text{at the output} \\ \dfrac{\partial Z_s}{\partial t}+U_h\cdot\nabla_h Z_s-w=0 \quad \text{at the free surface } z=Z_s(x,y,t) \\ Q_d=0.01372\left[1-0.2\cos(0.01\pi t)\right] \qquad Z_{sd}=0.114\text{m} \end{cases}$$

- **Physical interface conditions** :

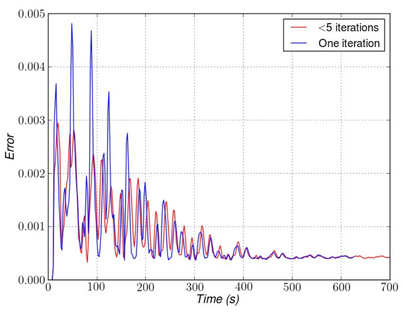
$$Q_{1D}(L,t)=Q_{3D}(L,t) \quad \text{and} \quad Z_{s1D}(L,t)=\overline{Z_{s3D}}(L,t)$$



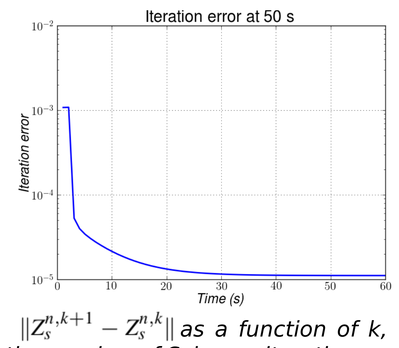
Free Surface evolution at position P1-subdomaine 1D



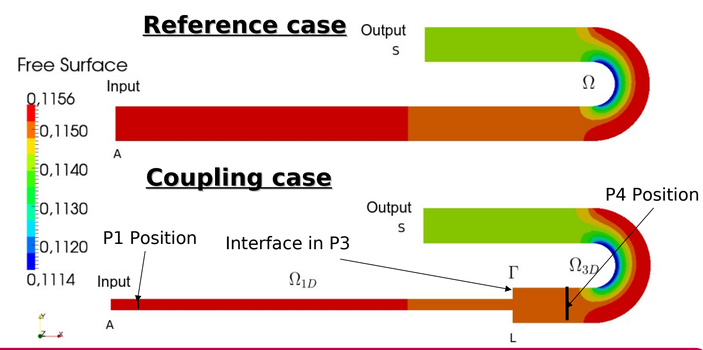
Free Surface evolution at position P4-subdomaine 3D



Norm of the error on the free surface between the coupled solution and the reference solution in the 3D area



$\|Z_s^{n,k+1} - Z_s^{n,k}\|$ *as a function of k, the number of Schwarz iterations*



Conclusion

- The coupling method is valid :
  - If the flow must be almost one-dimensional in the 1D domain
  - If the interface 1-D/3-D must be located in this area.
- The simple coupling algorithm gives almost the same results than the reference full 3-D simulation in our simplified case.
- For complex cases, it’s possible to use Schwarz based coupling algorithm to improve accuracy

Perspective

- Definition of a test-case more complex (La Rochelle)
  - Validation this iterative algorithm
  - Using more complex interface conditions, in order to ensure a fast convergence

CRISMA Consortium

The CRISMA project (www.crismaproject.eu) is co-ordinated by VTT Technical Research Centre of Finland. The consortium counts 17 partners from 9 countries, representing end-users, research and industry. The project ends in August 2015.

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